JEFFREY ELDRIGE

Transformer Lab

SUPPLIES & EQUIPMENT

2- 400 Coils, 2- various coils, U-shape core, AC power supply, AC voltmeter, AC Ammeter

Introduction

Transformers are useful when using alternating current to increase or decrease voltage. Two coils are connected through using an iron core which allows an alternating magnetic field to flow through a coil to induce an electromotive force. The relationship between the input voltage and output voltage is the ratio of the number of coils.

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

The power supply setting and the voltmeter are set to rms.

Procedure:

1. Setup the coils and core as shown in Figure 1. In the diagram, the coil to the left will be referred to as the primary coil, and the one to the right will be the secondary coil. Note that we are putting in an alternating current to the primary at one voltage level and reading the output at the secondary.

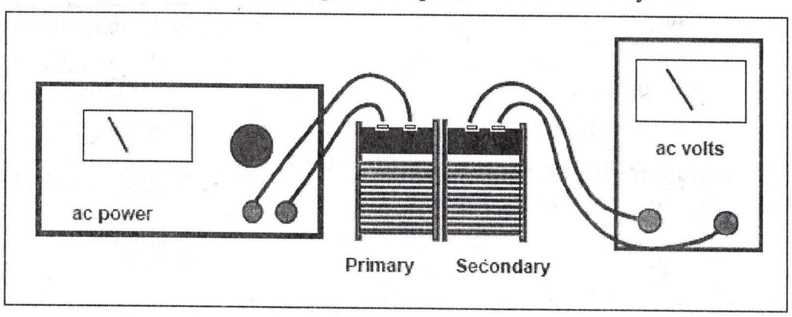


Figure 1

2. With the 400-turn coil as the primary and the 400-turn coil as the secondary, adjust the input voltage to 6 Volts a.c. Measure the output voltage and record your results. .59
3. Repeat step 2 after inserting the straight cross piece from the top of the U-shaped core. Record your results. (See Figure 2.)

4. Repeat step 2 after placing the coils on the sides of the open U-shaped core. Record your results.

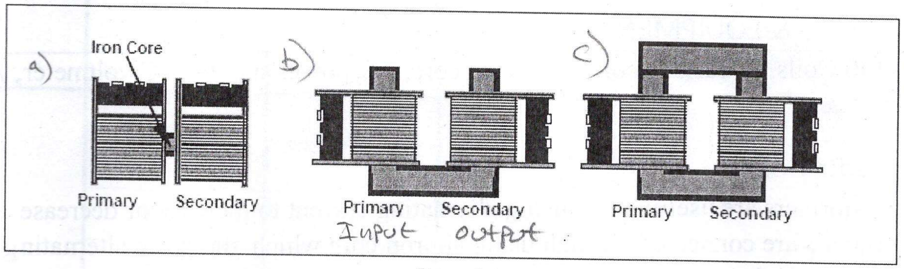


Figure 2

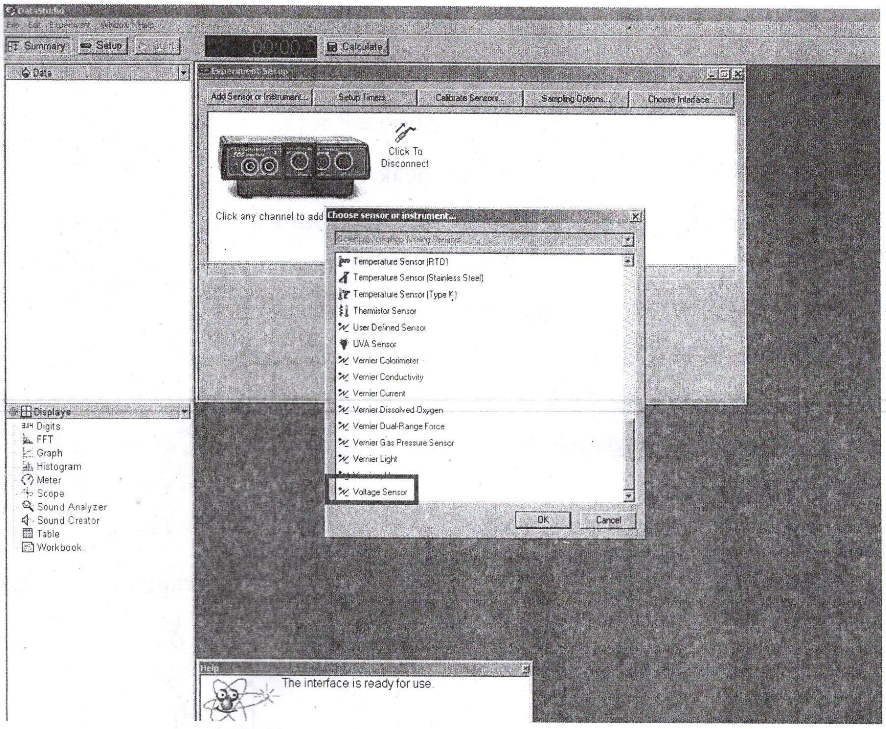
	ber of Turns					
	ary Coil	ndary Coil	V	ut V	nt Change $100 \times \frac{(V_{output}-V_{input})}{V_{input}}$	
	400	400				
a)			6 volts	.59	$\left(\frac{.59-6}{6}\right) \times 100$	-90.17%
Single Core			6 volts	3.01	$\left(\frac{3.01-6}{6}\right) \times 100$	-49.83%
b)			6 volts	2.36	$\left(\frac{2.36-6}{6}\right) \times 100$	-60.67%
c)			6 volts	5.85	$\left(\frac{5.85-6}{6}\right) \times 100$	-2.5%

5. Finally, repeat step 2 after placing the cross piece over the U-shaped core. Record your results.

Question:

Which core configuration gives the maximum transfer of electromagnetic effect to the secondary coil? Why do you think that is the case?

The 3rd configuration results in significantly larger electromagnetic effect. Bridging the gap across the top of the dual-pronged core effectively doubles the amperage passed over the surface.



6. Using the core configuration which gives the best output voltage compared to input voltage, select two different coils. The one with the higher number of coils will be your primary coil. Connect one Voltage Sensor to the secondary coil and the other Voltage sensor to the primary coil, both connect to the Science Workshop 500 Interface. Setup DataStudio, select Voltage Sensor for each port. <u>Set the sampling rate</u> to at least 1000Hz (the higher the better). Then select Graph to see the data. Once the voltage across the primary coil starts, Press the Start button and start recording the voltage across both the secondary coil and primary coil. (**Note**: If you are seeing a straight line at 10V that means you have the wrong coil acting as the primary coil. Data Studio maxs at 10V)

Question:

Observe the plot, does the plot make sense? If so why? If not why not?

7. Look at the graph you should see two curves, there should be one with a higher voltage than the other.

Which coil has the higher voltage (Primary vs Secondary)?

PRIMARY

Average 3 minimum peak values and 3 maximum peak values

Primary Coil N= 400 (RED)

Voltage	1	2	3	Average (V)
Minimum Peak	9	9	9	9
Maximum Peak	8.7	8.7	8.7	8.7
	Average Voltage peak for Primary Coil (V_{0P})=			8.85

V_{oP}

Secondary Coil N= 40 (GREEN)

Voltage	1	2	3	Average (V)
Minimum Peak	8	8	8	8
Maximum Peak	8	8	8	8
	Average Voltage peak for Secondary Coil (V_{0S})=			8

V_{oS}

$\frac{V_p}{V_s} = \frac{8.85}{8} = 1.10625$

[INTENSITY]

$\frac{N_p}{N_s} = \frac{400}{400} = 1$

What is the percent error between $\frac{V_p}{V_s}$ and $\frac{N_p}{N_s}$, assume the ratio of the coils is the theoretical value?

$\left(\frac{1.10625 - 1}{1}\right) \times 100 = 10.625\%$

Do you expect these values to be equal, why?

8. Now use the voltmeter to record the voltage for the Primary and Secondary coil for the configuration in step 6. Voltmeters display the RMS values.

$\times\sqrt{2}$

Voltmeter Voltage (V_{VP}) for Primary Coil=__6 V____ $\times\sqrt{2}$

Voltmeter Voltage (V_{VS}) for Secondary Coil=_5.85 V____

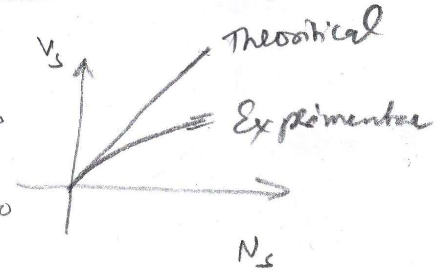
First Table

How does the values for the peak voltage on Data Studio compare to the voltage on the voltmeter? The values seem significantly different. However, for both the primary and secondary coils, the Data Studio measurements differ by a factor of $\sqrt{2}$, nearly exactly.

(A) Multiply the voltmeter reading by $\sqrt{2}$. What is the percent error between the peak value (V_{OS}) and the $\sqrt{2}$ V_{VS}? (B) Are these values close? Which one did you use as the theoretical value and why?

(A) Primary coil (P)
$6 \times \sqrt{2} = 8.485$
Secondary coil (S)
$5.85 \times \sqrt{2} = 8.273$

(B) % ERROR
(P) $\left(\frac{8.48-8}{8}\right) \times 100$
(S) $\left(\frac{8.273-8}{8}\right) \times 100$



varying primary
11.46
5.9
2.92

9. Disconnect the Data Studio setup.
10. Using the core configuration which gives the best output voltage compared to input voltage (from first part of the lab), try varying the primary and secondary coils. Use an input voltage of 6.0 volts a.c. Use the voltmeter to measure the input and output voltages. Record in the table below. (Input should stay consistent.)

Core Configuration:____________________________

$\frac{V_P}{V_S} = \frac{N_P}{N_S}$

V_S V_S N_S ?

ber of Turns				
ary Coil (N_P)	dary Coil (N_S)	V_P	ut V_S	$V_S = \frac{N_S}{N_P} V_P$
200	200	6 V	5.89	6 V
	400	6 V	11.46	12 V
	800	6 V	16.59	24 V
	1600	6 V	18.36	48 V

$V_S = \frac{N_S}{N_P} V_P$

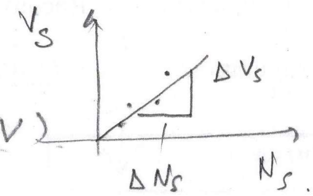
turns

Choose a data set for one consistent Primary coil. Plot the output voltage (y-axis) versus the number of coils in the Secondary coil (x-axis).

What is your slope on the graph?

.008

What does your slope represent? slope $= \dfrac{\Delta V_s}{\Delta N_s}$ (V)



The slope represents the degree of change in Voltage per unit increase in turns of wire on the secondary coil.

What is the percent error between the slope value and the theoretical value (derived from the transformer equation)?

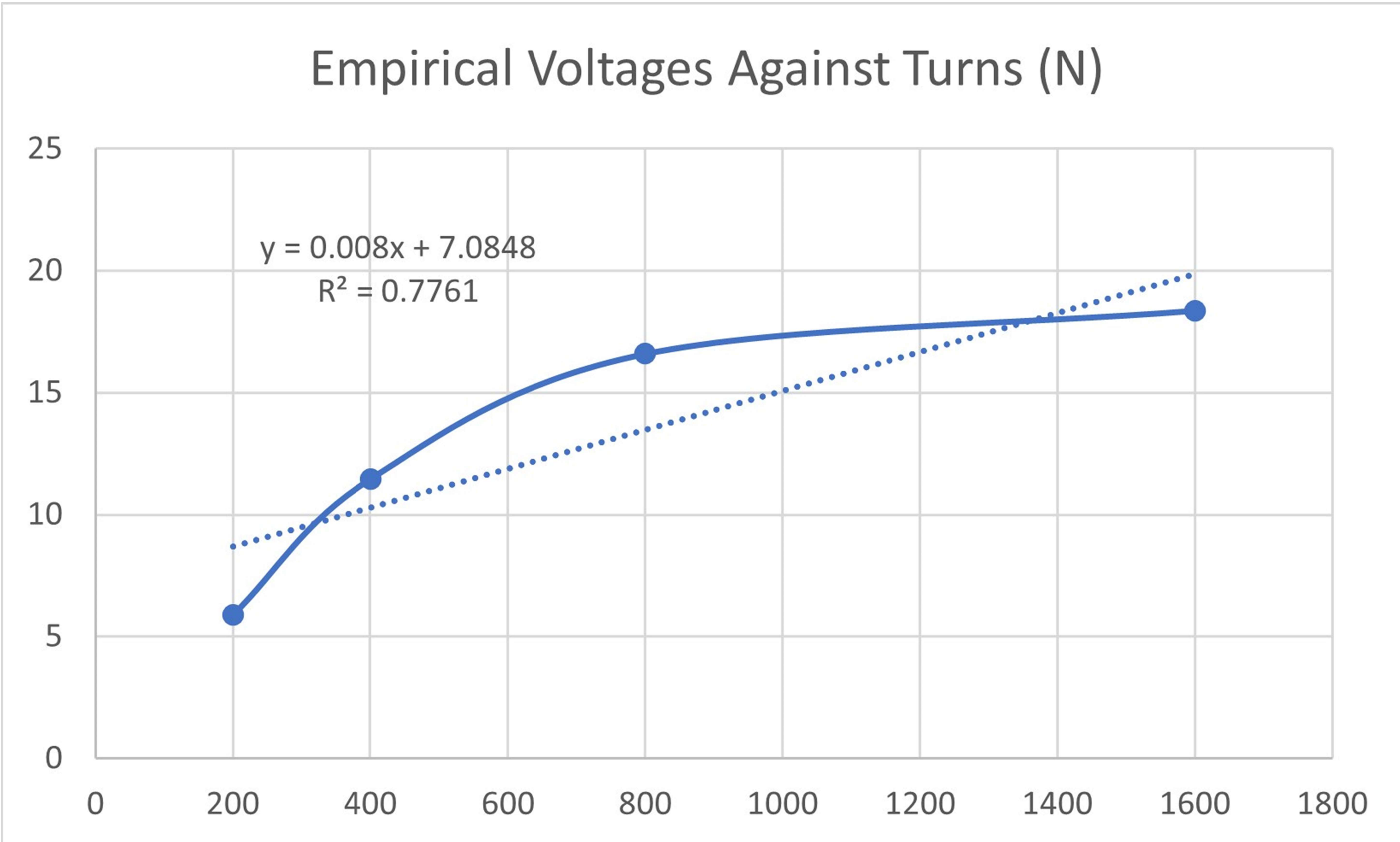
$$\left(\frac{.008 - .03}{.03}\right) \times 100 = -73\%$$

Summarize what is the objective, how did you perform, what you learned.

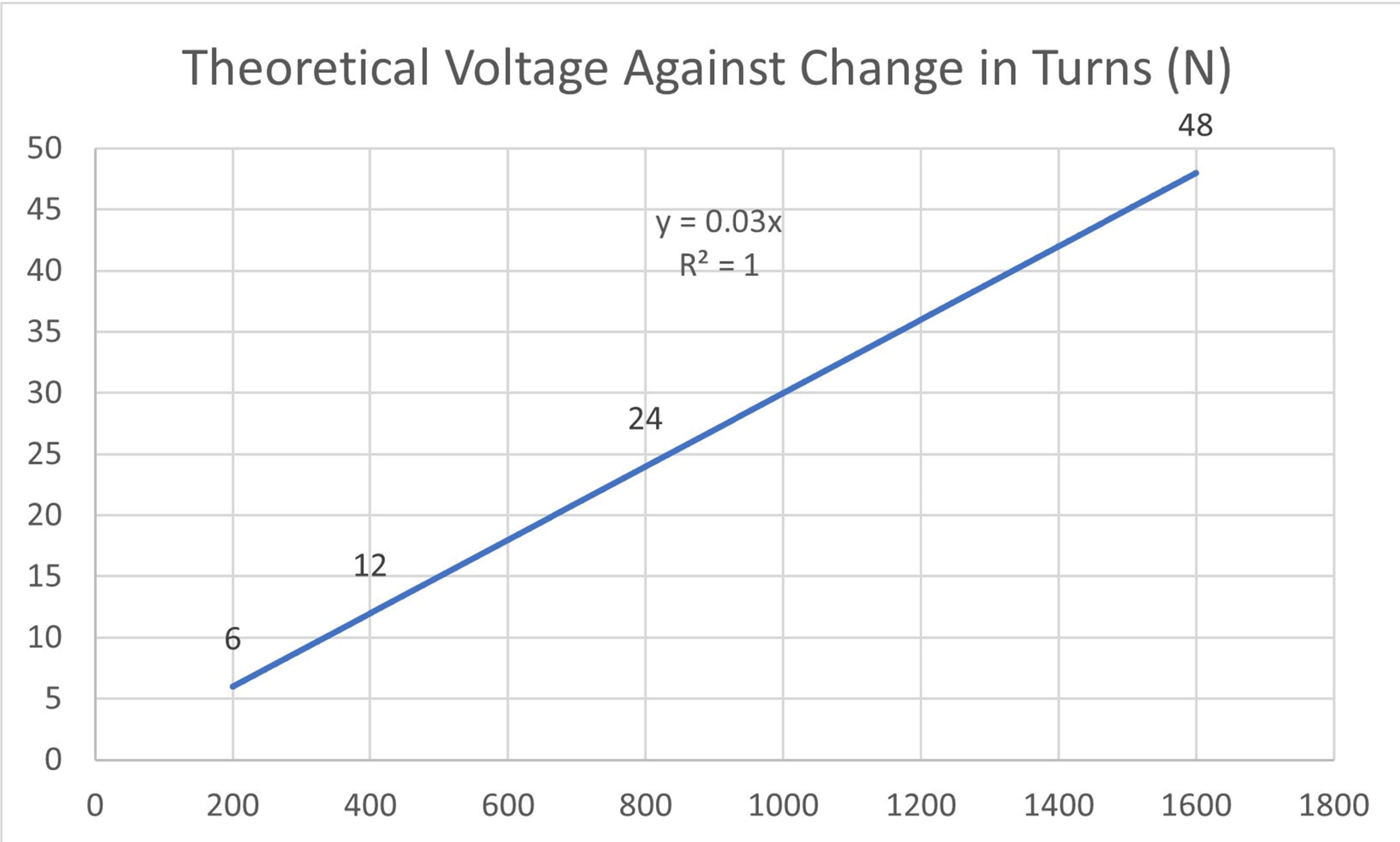
This activity examines the affect on an electromagnetic fields' intensity that increasing the number of turns on conducting coils in a 2 coil circuit.

The interaction of these components is DIRECT. As the # of wire turns increases, so does the proportion of the input current that that is conveyed across the transformer.

Still, this is not a "one-way" interaction. The material (solid conducting metal) and the structure of the apparatus are essential components. The wire turns must be wound on insulating material (plastic) in order to hold and direct the input — but this reduces the conductivity of the wire turns. Placement of the coils around the (solid) metal arms of the transformer suppliment this conductivity loss by puttin the coils in physical proximity to a metal of high charge capacity. The output Voltage is literally at the center of each coil. The more wire turns on the coil, the more of the transformer's current the coils will take up and transport.



Empirical Voltages Against Turns (N)
y = 0.008x + 7.0848
R² = 0.7761
25
20
15
10
5
0
0
200
400
600
800
1000
1200
1400
1600
1800


Theoretical Voltage Against Change in Turns (N)
y = 0.03x
R² = 1
6
12
24
48
0
5
10
15
20
25
30
35
40
45
50
0
200
400
600
800
1000
1200
1400
1600
1800

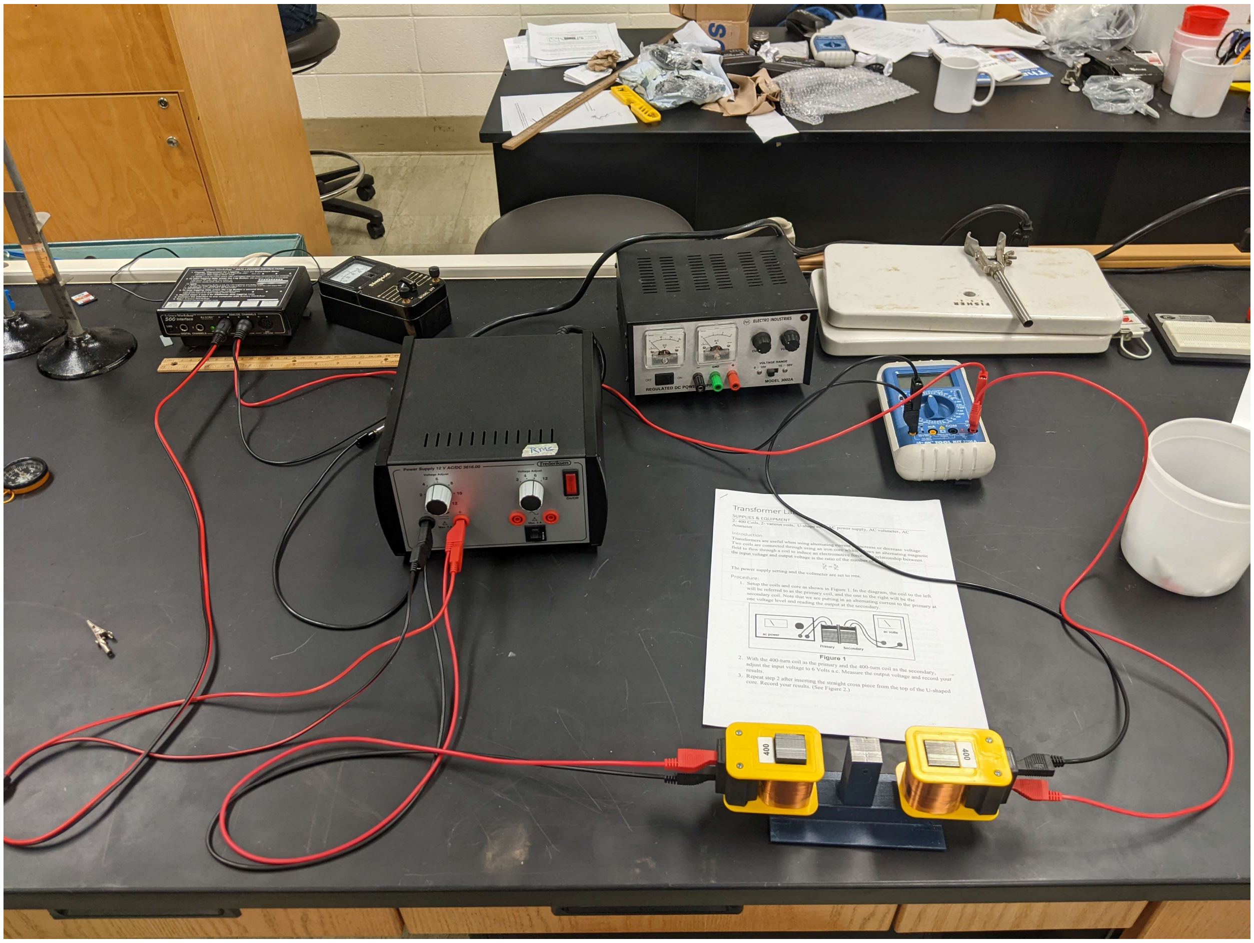
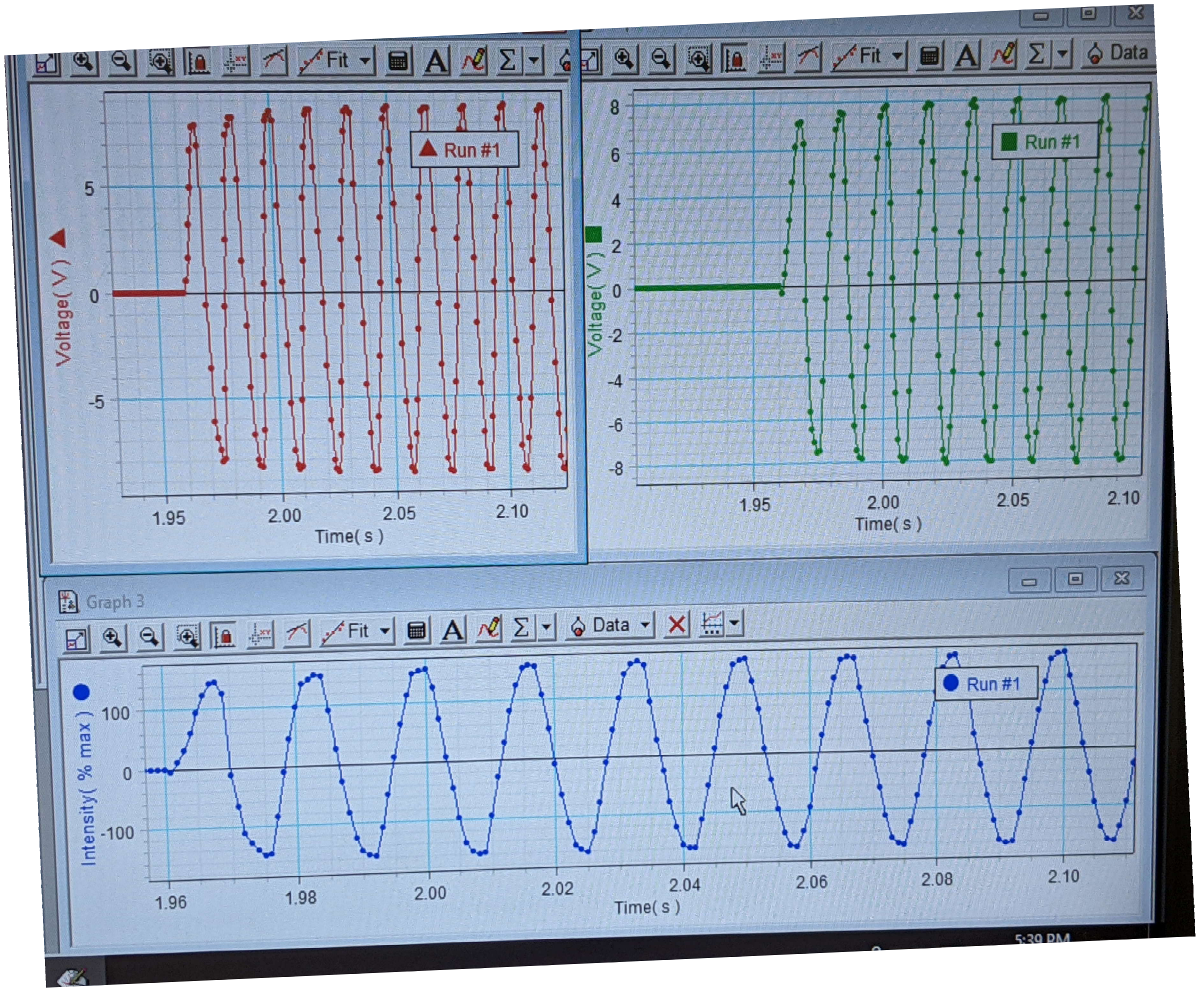
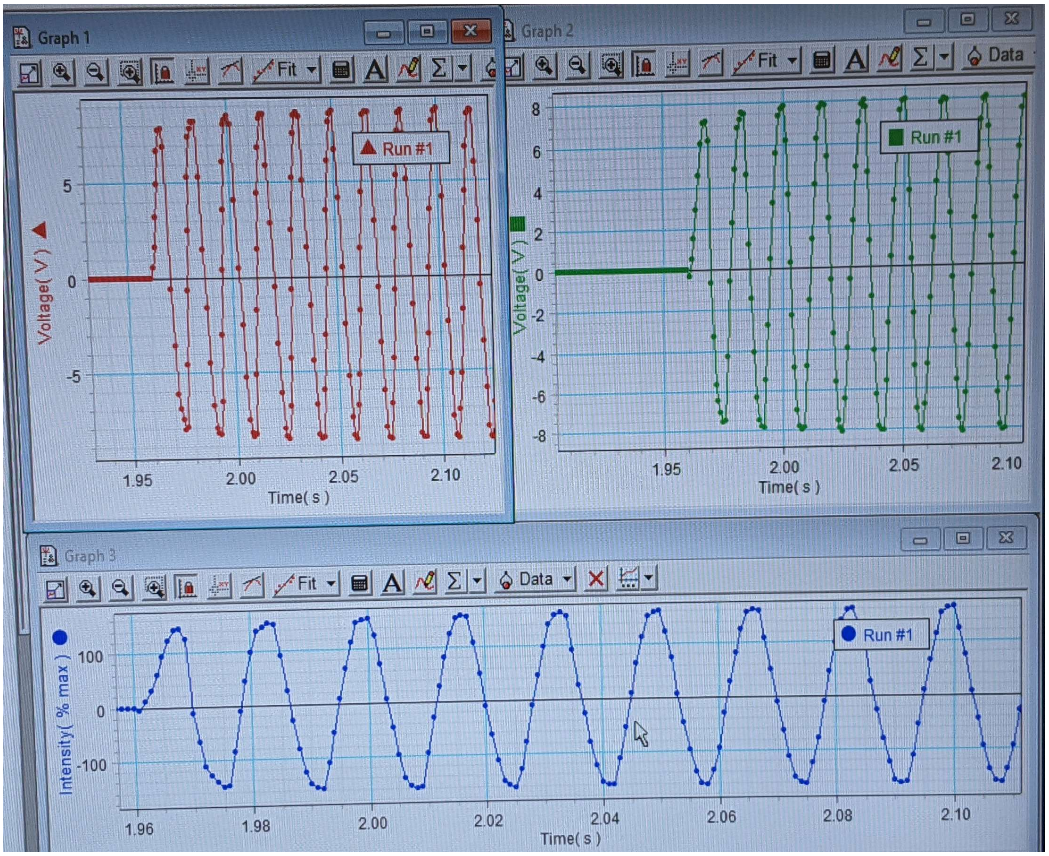


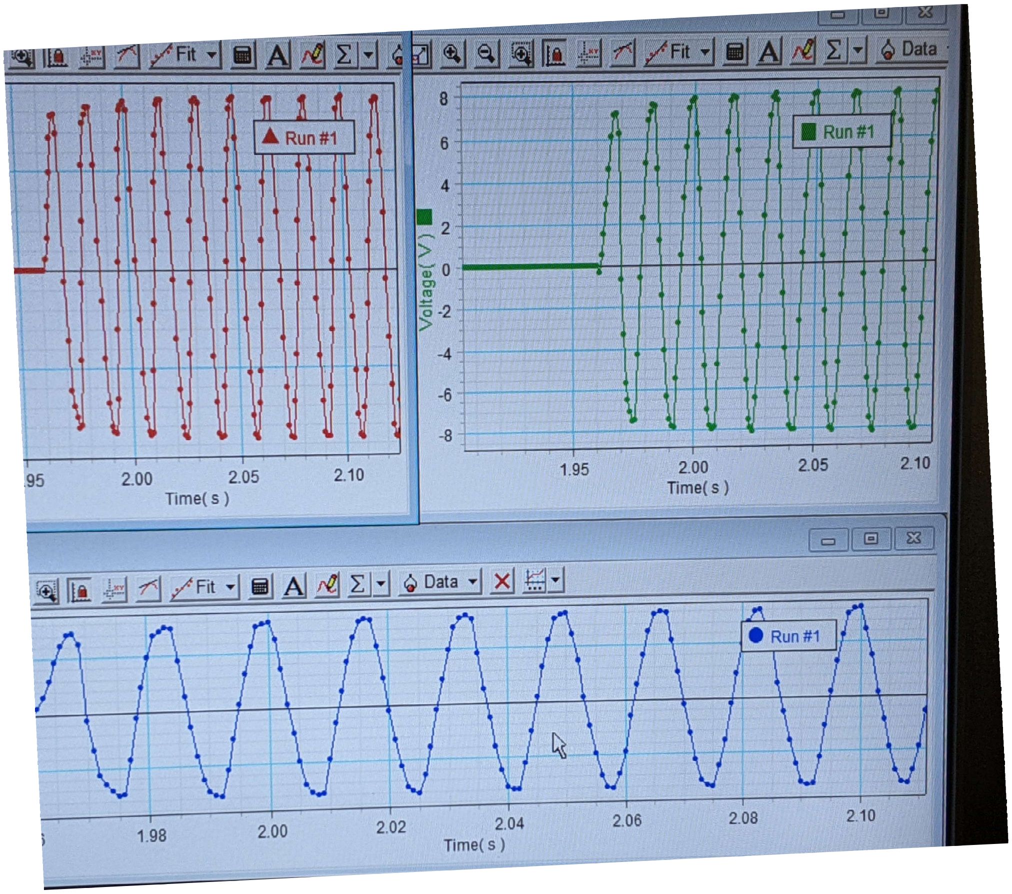
Figure 1
400
400



Fit
Data
Run #1
Voltage(V)
Time(s)
Graph 3
Intensity(% max)



Graph 1
Fit
Run #1
Voltage(V)
5
0
-5
1.95
2.00
2.05
2.10
Time(s)
Graph 2
Fit
Data
Run #1
Voltage(V)
8
6
4
2
0
-2
-4
-6
-8
1.95
2.00
2.05
2.10
Time(s)
Graph 3
Fit
Data
Run #1
Intensity(% max)
100
0
-100
1.96
1.98
2.00
2.02
2.04
2.06
2.08
2.10
Time(s)



Fit
Data
Run #1
Voltage (V)
8
6
4
2
0
-2
-4
-6
-8
.95
2.00
2.05
2.10
1.95
Time(s)
1.98
2.02
2.04
2.06
2.08